

Data Mining in Radiation Portal Monitoring

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Currently deployed passive gamma and neutron detectors screen for illicit nuclear material. Archived data can help to evaluate special nuclear material detection probabilities (DP) and to investigate several related issues, including: 1) nuisance gamma alarms arising from naturally occurring radioactive materials (NORM), 2) sensor fusion options, and 3) radioisotope identification (RIID) performance.

Figure 1 shows a screening location where four detector panels each record a neutron and a low- and high-energy gamma count every 0.1 s for 5–20 s, resulting in a 12-component time series of 50 to 200 observations.

Nuisance alarms due to NORM reduce DPs for threats. Strategies for recognizing common NORMs, such as cat litter or ceramics, depend on the sensor energy resolution. Figure 2 illustrates the extent to which different, common NORM categories have a signature using a 2D representation for each profile. The scaled maximum low-energy count range vs the scaled maximum ratio of the high- to low-energy counts is plotted for each of several profiles of eight NORM categories. One of the best methods using the systems described here (two-energy gamma and neutron in each of four panels) uses a nonparametric density-estimation method for pattern recognition [1,2] applied to tens of features such as those used in Fig. 2, derived from the 12-component time series for each profile. Although some common NORMs do appear to have a signature, at present any vehicle having a large count is subject to further investigation. Such additional investigation and measurement result in slower vehicle transit times.

Vehicles that alarm in primary screening go to secondary screening where higher resolution gamma and X-ray measurements are made. There are several feasible options for combining information from primary and secondary screenings to enhance DPs. Some options have been quantitatively evaluated [3,4]. By sensor optimization, we mean to optimize the expected DPs with respect to the sensor thresholds, sensor ordering and protocol, and/or the alarm rules. Sensor protocol involves, for example, whether the sensors send only pass-fail information or more complete data, and whether the declared cargo is allowed to impact the calculated likelihoods.

RIID performance is a major challenge for low-, medium-, or even high-resolution gamma spectra. On the basis of a small test data set, we have found that medium-resolution detectors such as the hand-held sodium iodide (NaI) detectors used in secondary screening appear to be competitive with high-resolution detectors. A current challenge is to evaluate the cost/benefit that medium-resolution NaI detectors might provide in primary screening, deployed as so-called advanced spectroscopic portals (ASP). ASP testing is ongoing to estimate low-, medium-, and high-resolution detector performance based on several metrics. One straightforward opportunity to improve RIID performance and testing appears to be spectral smoothing; adjustments are made to preserve key spectral regions of interest such as peak areas. RIID algorithms can be tested for more measurement scenarios by reducing count time and by augmenting real spectra with realistic synthetic spectra. Model uncertainty will play a key role in assessing the adequacy of synthetic spectra.

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Fig. 1. Example screening location with four detector panels surrounding the vehicle.

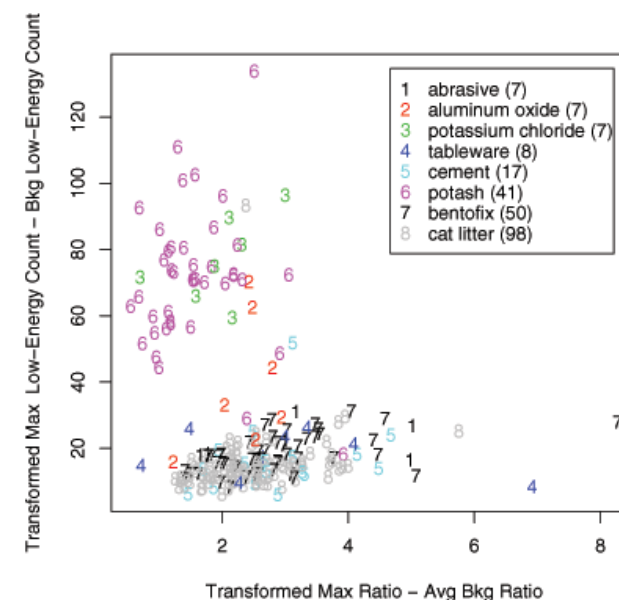


Fig. 2. The scaled maximum low-energy gamma count versus the scaled maximum ratio (adjusted by subtracting the corresponding average values in the background data taken just prior to the vehicle profile) for each of several profiles of eight common NORMs. The number of profiles for each NORM category is given in parentheses in the figure legend.

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